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Risk factors for heat-related illness in Washington crop workers

June T. Spector, MD, MPH[1,2,§], **Jennifer Krenz, MS, MPH**[1], and **Kristina N. Blank, BS, MPH**[1]

[1]University of Washington, Department of Environmental and Occupational Health Sciences, Seattle, Washington, USA

[2]University of Washington, Department of Medicine, Seattle, Washington, USA

Abstract

Background—Crop workers are at high risk of heat-related illness (HRI) from internal heat generated by heavy physical work, particularly when laboring in hot and humid conditions. The aim of this study was to identify risk factors for HRI symptoms in Washington crop workers using an audio computer-assisted self-interview (A-CASI) instrument that has undergone reliability and validity evaluation.

Methods—A cross-sectional A-CASI survey of 97 crop workers in Washington State was conducted during the summer of 2013. Potential HRI risk factors in demographic, training, work, hydration, clothing, health, and environmental domains were selected *a priori* for evaluation. Mixed effects logistic regression was used to identify risk factors for self-reported symptoms associated with heat strain and HRI (dizziness/light-headedness or heavy sweating) experienced at work in hot conditions.

Results—An increase in age was associated with a lower odds of HRI symptoms (odds ratio [OR] 0.92; 95% confidence interval [CI] 0.87–0.98). Piece rate compared to hourly payment (OR 6.20; 95% CI 1.11–34.54) and needing to walk for more than three minutes to get to the toilet, compared to less than three minutes (OR 4.86; 95%CI 1.18–20.06), were associated with a higher odds of HRI symptoms.

Conclusions—In this descriptive study of risk factors for HRI symptoms in Washington crop workers, decreased age (and less work experience), piece rate pay, and longer distance to the toilet were associated with self-reported HRI symptoms. Modifiable workplace factors should be considered in HRI prevention efforts that are evaluated using objective measures in representative working populations.

Keywords

agricultural workers; farmworkers; crop workers; heat-related illness; risk factors

[§]Corresponding Author: June Spector, MD, MPH, Department of Environmental & Occupational Health Sciences, 4225 Roosevelt Way NE, Suite 100, Seattle, WA 98105, Tel: (206) 897-1979.

INTRODUCTION

Internal heat generation from heavy physical work, particularly when performed in hot and humid environmental conditions, contributes to the development of exertional heat-related illness (HRI) in agricultural workers. Heat-related illnesses can range in severity from relatively mild (e.g. heat rash) to heat stroke and death. Unlike classical heat stroke, exertional HRI can affect young, otherwise healthy workers.[1] Crop workers, who often perform physically demanding tasks in workplace environments without adequate cooling or hydration, are disproportionately affected.[1–3] Between 2003 and 2008, the United States (US) agriculture, forestry, and fishing sector had the highest mean heat fatality rate (approximately 0.3 deaths/100,000 full-time workers) compared to all US industries (0.02 deaths/100,000 full time workers).[1,2] In Washington (WA) State, the average annual HRI workers' compensation claims incidence rate per 100,000 full-time equivalent workers in the agriculture and forestry sectors between July and September from 1995 and 2009 was 15.7.[3] The actual rate of HRI is probably substantially higher than estimated using workers' compensation data because HRI is likely under-recognized and under-reported.[3] The risk of HRI is expected to increase over time as the frequency and severity of heat events increases.[4–6]

The principles of human heat balance, physiology, and the results of research studies, primarily in athletes and the military, form the basis for recommendations and regulations intended to prevent HRI in outdoor workers.[1,7–9] Workplace safety standards adopted in WA and California focus on hydration, rest, acclimatization, clothing, emergency plans, shade, and education, including education about personal HRI risk factors such as certain chronic conditions and the use of certain medications. In addition to these factors, formative studies in agricultural workers have described additional potential barriers to HRI prevention, including a long distance to the restroom, perceptions of water located near restrooms as potentially contaminated, and a perceived benefit of weight loss from sweating when wearing layers of clothing.[10–14] Piece-rate pay, or payment per amount of work done, has been reported to increase injury risk though increased risk-taking behavior and fatigue[15] and may also influence HRI risk by incentivizing increased exertion and fewer breaks for rest, hydration, and restroom use.

Although a number of studies have sought to characterize HRI in agricultural workers using survey approaches,[16–19] no study has identified HRI risk factors in crop workers using a survey with published validity and reliability characteristics. Without such evaluations, the extent of misclassification due to information bias, and its impact on the interpretation of results, are unclear. Further, studies indicate that audio computer-assisted self-interview (A-CASI) instruments, which consist of narrated questions and answer choices with visual aids, are efficient in field settings, effective in low literacy populations, do not suffer from interviewer bias, and lead to more accurate self-reports of sensitive information when compared to surveys administered by trained interviewers.[20,21] The aim of this descriptive study was to identify risk factors for self-reported HRI symptoms in WA crop workers, who are largely Spanish speaking, using an A-CASI instrument that has undergone reliability and validity evaluation. The hypothesis was that, in addition to "traditional" risk factors, including personal risk factors, clothing, hydration, acclimatization, and environmental

factors, other modifiable workplace factors, such as those related to workplace water and restroom characteristics and payment schemes, are associated with exertional HRI in this population.

METHODS

Survey development and evaluation

Survey topics were identified using information obtained from a literature review, analyses of WA workers' compensation HRI claims,[3] and focus group sessions with WA crop workers.[13] Survey topics included work history and current work activities; work payment methods; breaks and hours typically worked; work exertion, hydration, cooling methods, and clothing; health and HRI symptoms; medications, alcohol and tobacco use; level of concern about workplace heat exposure; and HRI training.

Survey questions were adapted from existing validated surveys when possible, modeled after questions from a validated A-CASI survey instrument designed to identify risk factors for cholinesterase depression in agricultural pesticide handlers in WA,[22] or developed by the research team when previously used, validated survey questions were not available. Assessment of workplace exertion was adapted from the Borg and OMNI Rating of Perceived Exertion scales. [23–25] Draft questions were developed in English and then translated into Spanish and audio recorded by bilingual and bicultural project staff members. Questions about factors that change over time, such as work tasks and activities, asked about the past week to minimize recall bias. In other contexts, one-week recall questions have yielded reliable and valid results.[26–28]

The survey was developed using Open Data Kit (http://opendatakit.org/), a freely available platform for Android devices. The survey included Spanish and English narrations of questions and photographs and illustrations, which were designed to be vivid and realistic, characteristics that have been shown to facilitate understanding in low-literate, Latino farmworkers.[29] A group of six crop workers representative of the study population evaluated the survey instrument for content validity and usability. The survey was iteratively revised based on this feedback and suggestions from collaborators at Oregon State University, who adapted the survey for use in a separate study of agricultural workers.[19] The final survey instrument consisted of 64 items.

Seventeen outdoor crop workers from one WA orchard participated in concurrent validity and test-retest reliability evaluation of the survey during the summer of 2013. These workers were observed by trained research staff, who recorded observations on clothing, the type and quantity of beverages consumed, how workers cooled themselves (e.g. sitting in the shade), when workers started and ended their work days, durations of employer-mandated and self-initiated breaks, and descriptions of tasks, during four workdays on standardized forms. Three of the four days occurred within one week, and observational data collected on these days were used for validation analyses. Body mass index (BMI) was calculated from measured height and weight as (weight[kg]/height[m]^2). Project staff members assigned work tasks to exertion categories based on the American Conference of Governmental Industrial Hygienists (ACGIH) Heat Stress Threshold Limit Value (TLV) metabolic rate

categories [30] and project staff consensus, with exertion ranging from “light” to “very heavy.” Demographic characteristics, work activities, and certain health characteristics that were not expected to vary over time were selected for reliability evaluation (Appendix 1). Questions that asked about activities or behaviors that were not observable at the workplace, such as medication use and chronic health conditions, were not evaluated for validity. Participants who were observed took the survey on the first and last days of observations (spaced 15 days apart).

Concurrent test-retest reliability and validity statistics (percent agreement and kappa coefficients) for survey responses are shown in Appendices 1 and 2, respectively. In general, survey questions covering demographics, health status, health conditions, training, health behaviors, and HRI appeared to be reasonably reliable (% agreement 71–100% or kappa 0.70–1.00, comparing participant responses at each survey administration day). Survey questions assessing work tasks, times, payment schemes, types of beverages consumed, workplace shade, and certain clothing questions demonstrated acceptable validity (% agreement between survey responses from the first survey administration day and field observations 71–100%).

Participant recruitment and survey administration

Adults engaged in outdoor, summer crop work in Central or Eastern WA were eligible to participate in the study. During the summer of 2013, bilingual and bicultural project staff members, who reside in Central and Eastern WA, contacted local orchard and farm supervisors and individual crop workers. Sampling was not random; research staff contacted growers and workers whom they felt were likely perform outdoor summer crop work. Research staff asked for permission from employers to recruit workers at their workplaces. Project staff travelled to workplaces or mutually-agreed upon meeting locations, explained the goals of the project, and asked eligible workers if they were interested in participating. Interested participants provided informed consent.

The survey was self-administered on touch screen tablets (Asus Eee Pad Transformer Prime 10.1 inch screen, ASUS Computer International, Fremont, CA, USA) to 100 participants from 9 workplaces (median [range] of 6 [2–28] participants per workplace) in Central and Eastern WA from July 2013 through September 2013. Twenty of these participants were additionally recruited to participate in the previously described reliability and validity studies (two dropped out in the middle of the study, and one did not complete the first survey, leaving 17 for the reliability and validity analyses). Comparisons between the full participant group (N=97) and the observation participants (n=17) are shown in Appendix 3. The University of Washington Institutional Review Board approved all study procedures.

Outcome and potential risk factors

The outcome was defined *a priori* as self-reported HRI symptoms (dizziness/light-headedness or heavy sweating, versus none of these symptoms, during a hot day at work in the past week). The survey asked about specific symptoms, as participants were not assumed to know which symptoms were associated with heat strain or HRI. This *a priori* combination of specific symptoms was used as a single outcome variable in the analyses. The outcome

definition (light-headedness/dizziness or heavy sweating) focused on symptoms that are both symptoms of HRIs and also reflect underlying physiological mechanisms that, when overwhelmed, can lead to heat stroke. Increased cardiovascular demands and heavy sweating (particularly without adequate fluid replacement) can lead to inadequate delivery of blood to the tissues and associated symptoms of light-headedness/dizziness, less efficient evaporative and convective heat loss, and a rise in core body temperature.[40] Symptoms of light-headedness/dizziness and heavy sweating are also associated with heat syncope and heat exhaustion. Of note, although fainting was included in the original outcome definition, no workers reported fainting. Heat rash, cramps, headache, fatigue, and nausea/vomiting were reported (Appendix 3) and can also be associated with HRI, but these symptoms were not included in the outcome definition because they are often caused by other illnesses and may not be directly related to underlying physiological mechanisms of interest. Dizziness/light-headedness can occur as a result of hypoglycemia in diabetics, particularly those taking certain diabetes medications. However, none of the participants that reported dizziness/light-headedness during a hot day at work reported being told by a health provider that they had diabetes. Reactive and fasting hypoglycemia is relatively rare in non-diabetics, particularly those that are relatively healthy (41).

Potential HRI risk factors in the following domains were selected *a priori* for inclusion in the risk factors analysis based on the existing scientific literature: 1) demographic; 2) HRI training in the past year; 3) work factors; 4) hydration; 5) clothing; 6) health; and 7) environmental conditions. Preference was given to potential risk factors for which corresponding survey questions had acceptable performance in reliability and validity evaluations (Appendices 1 and 2). The variables included in the risk factors analysis are shown in Table 1.

Hourly temperature and relative humidity data were obtained from Washington State University's AgWeatherNet weather station program,[31] and used to calculate hourly heat indices using standard methods,[32,33] as previously described.[3] Maximum daily heat indices for self-reported work hours for each participant were used to compute mean maximum daily heat indices over the past week (HI_{max}), as the past week was the duration of recall of most survey questions.

Analyses

Ninety-seven participants' responses were included in the analyses. Of the 100 participants to whom the survey was administered, three participants' responses were excluded from the descriptive analyses because they did not complete the survey (n=1) or they indicated that they did not work during the preceding week (n=2), the timeframe asked about in the majority of the survey questions.

Separate mixed effects logistic regression models, with random effects for workplace, were constructed for each domain of risk factors. All variables were coded as categorical variables, as shown in Table 1, except age (years), HI_{max} (°F), and BMI (kg/m^2), which were coded as continuous variables, in regression models. Variables with a P-value < 0.50 in single-domain models were entered together into a multi-domain mixed effects logistic

regression model, with a random effect for workplace, of HRI. Statistical analyses were performed using Stata 10 (StataCorp, College Station, TX, USA).

RESULTS

Participant demographic characteristics

Characteristics of the study population are shown in Table 1, and additional details are shown in Appendix 3. The majority (91%) of participants were born in Mexico, and nearly all identified as Latino/a. The mean (standard deviation) age was 41 (13), 53% of participants were male, and over half of participants reported only a primary school education. Fifty-nine and 11% of participants reported being able to read very well in Spanish and English, respectively. The majority of participants reported working with tree fruit, and common tasks included harvesting and thinning green fruit.

Health and HRI symptoms

The mean (standard deviation) BMI was 28 (4) kg/m^2. Thirteen percent of participants reported that a healthcare provider has told them they have diabetes, and 12% reported taking medications for hypertension in the past week. Approximately one third of participants reported experiencing HRI symptoms (light-headedness/dizziness or heavy sweating) during a hot day at work in the past week. Ninety percent of participants reported starting work for the season at least three weeks before the survey, and the mean (standard deviation) number of days worked in the past week was 4.9 (1.5), indicating that most participants were likely acclimatized to the Central/Eastern Washington outdoor summertime environment.

Work factors, HRI training, and environmental conditions

Seventy-four percent of participants reported feeling that they were allowed to take extra breaks if needed to rest or drink water. Approximately one third of participants reported usually having to walk for more than three minutes to get to the toilet. Only about one third of workers reported receiving training about working outdoors in the heat or health effects of working in the heat in the past year. Approximately half of the participants reported being paid by the piece. The mean (standard deviation) HI_{max} during reported working hours was 84 (2) °F. The temporal and geographical distribution of HI_{max} during the study period is described in Figure 1. During the study period, the maximum daily temperature ranged from 77°F to 97°F. Mean temperatures in July and August in Central/Eastern Washington area are typically in the 70s °F.[31]

Hydration and cooling

Workers reported drinking water (96%), including water brought from home and provided at work, soda (31%), sports drinks (23%), juice (8%), energy drinks (6%), and coffee or tea (4%) at work. Fifty-seven percent of workers reported usually drinking water every thirty minutes or more in the past week. The majority (92%) of workers reported access to shade from trees at work. Nearly all workers reported wearing some type of head covering, over three quarters of participants reported wearing a light-colored shirt, and 13% reported

wearing some type of personal protective equipment (3% Tyvek® or chemical resistant suits; 1% respirator) at work in the past week.

Risk factors for HRI symptoms

Participants reporting HRI symptoms (light-headedness/dizziness or heavy sweating) in the past week, compared to participants who did not report HRI symptoms, were more likely to report being female, not having HRI training the past year, being paid by the piece, not feeling that they were allowed to take extra breaks to rest or drink water, working harder, having a greater distance to walk to the toilet, drinking caffeine, drinking less frequently, and having good or fair (versus excellent or very good) general health (Table 1). The mean (standard deviation) age was lower in participants reporting HRI (36 [13] years), compared to participants not reporting HRI (43 [13] years), and participants reporting HRI were less likely to report being told by a healthcare provider they had diabetes or using anti-hypertensive medications.

Results from the final multi-domain mixed effects logistic regression model are shown in Table 2. An increase in age was associated with a lower odds of HRI (odds ratio [OR] 0.92; 95% confidence interval [CI] 0.87–0.98). Piece rate compared to hourly pay (OR 6.20; 95% CI 1.11–34.54), and needing to walk for more than three minutes to get to the toilet, compared to less than three minutes (OR 4.86; 95%CI 1.18–20.06), were associated with a higher odds of HRI.

DISCUSSION

In this descriptive study, modifiable workplace factors, including a longer distance to the toilet and piece-rate, versus hourly, payment, were associated with self-reported HRI in Washington crop workers. Although the risk of HRI is particularly high in tropical and sub-tropical areas of the world,[34] HRI can occur even in temperate climates when internal heat generation is substantial and clothing is not optimal[35] and indoors when effective cooling mechanisms are not available. In this study of outdoor crop workers, approximately one third of participants reported experiencing HRI symptoms (dizziness/light-headedness or heavy sweating) in the past week. There was no significant association between environmental conditions (HI_{max}) and the risk of HRI. This finding is not surprising given the contribution of other factors, including those that affect internal heat generation and acclimatization, to exertional HRI. In addition, although the study did encompass hotter work conditions than are typical on Central/Eastern Washington summer days, there was relatively little variability in environmental conditions during the study period.

Although previous studies have reported associations between piece rate pay and increased injury risk,[15] this is the first study reporting an association between piece rate, versus hourly, pay and HRI in crop workers. Economic incentives have been reported to motivate workers to labor harder and faster.[15] Increased exertion, and associated metabolic heat generation, may in part mediate the effect of piece rate pay on the development of HRI. Managers may choose piece rate pay to incentivize increased productivity for certain physically demanding tasks such as harvesting hard fruit. Although limited by a small sample size, adjustment for task and exertion in secondary analyses did not fully attenuate the association between piece

rate pay and HRI symptoms, suggesting that there may be other effects of piece rate pay on the development of HRI symptoms. Further investigation is needed.

In validity analyses, self-reported exertion did not correspond optimally with observed exertion level (Appendix 2). The task-based metabolic rate estimates used by field observers did not take into account personal characteristics that may affect metabolic rate, such as age and certain health conditions, or variation in procedures that involve different levels of physical exertion for a single task. Self-reported exertion using the Borg scale approximates heart rate in certain circumstances.[23] An adaptation of the Borg and OMNI Rating of Perceived Exertion[24,25] scales that was most accessible to the study population was used, as the original versions of these scales were felt to be difficult to interpret by participants in initial content validation and feedback sessions. Since metabolic heat generation is a key consideration when determining the risk of exertional HRI, these findings should be confirmed using objective measures to estimate metabolic rate, such as heart rate measurements and actigraphy. Such methods could also help distinguish between effects of metabolic heat production and environmental heat exposure, relationships that were not directly assessed in this study.

Piece rate pay may encourage taking less time for rest and hydration. Although not statistically significant, an increased risk of HRI among workers who reported that they felt they were not allowed to take extra breaks to rest or drink water, versus those who felt they could take extra breaks, was observed. Given the association between piece rate pay and adverse health and safety outcomes,[15] consideration should be given to more frequent mandatory breaks, separate pay for breaks, or transitions to hourly pay above a certain heat exposure threshold in these workers. The effects of such interventions on health and productivity, which is also affected by heat stress,[36] should be evaluated using objective methods in representative populations.

A longer distance to the toilet was associated with HRI in this study. In a post-hoc analysis, no evidence of effect modification of the relationship between distance to the toilet and HRI by gender was present. These findings are consistent with previous reports that have identified properties of workplace restrooms, including accessibility and proximity to drinking water, as barriers to adequate hydration.[13,14] One approach to facilitate close proximity to restrooms involves hooking portable toilets up to vehicles that are moved to locations where workers are working. However, the movement of crop workers and work throughout the day can be complex, and movement of restrooms could pose logistical challenges. Additional analyses of objective data on the geographical locations of workers and restrooms at the worksite over time, for example using global positioning sensors, could be helpful in developing recommendations for optimal locations and movement of portable toilets.

An increase in age was associated with a lower risk of HRI in this study. Unlike classical heat stroke, which is more common in the elderly and very young, occupational HRI has been reported to occur in relatively young workers, particularly workers who generate metabolic heat from heavy physical labor in hot environments.[1,3] While age was not significantly associated with exertion level, increased age was associated with working more

seasons in agriculture. There was no assessment of whether experience itself might impart HRI preventive knowledge, as HRI knowledge was not assessed.

Over half of survey participants reported not receiving HRI training in the past year. Yet HRI training is required annually per the Washington Agriculture Heat Rule between May 1 and September 30 when outdoor agricultural workers are exposed to temperatures above 77°F to 89°F, depending on the type of clothing worn.[7] Whether the low prevalence of training was due to an actual low prevalence of training or workers not remembering, or not being aware of, having received annual HRI training was not assessed. Further evaluation of the prevalence and effectiveness of HRI training strategies that addresses barriers to HRI prevention and treatment in this population are needed.[13,14]

Although previously published studies have utilized self-reported hydration questions, including hydration frequency questions,[16–19] the validity of these questions has not previously been reported. Self-reported questions assessing the frequency of water consumption did not perform optimally on validity testing (Appendix 2), and validation of hydration frequency was difficult to perform using field observations. Self-reported hydration questions may also suffer from recall bias. Objective measures of hydration status, such as plasma and urine osmolality or urine specific gravity[37] should be used in future studies if possible. Although not statistically significant, a reduced risk of HRI in workers who reported drinking caffeine was found. The role of caffeine in the development of HRI is controversial,[38] and it is possible that hydration, even with caffeinated beverages, is preferable to no hydration.

The clothing variable in the main analysis addressed whether or not a light-colored shirt was usually worn at work over the previous week. The analysis did not focus on pants, in part because previous research in tropical environments has indicated no difference in body temperature when comparing workers wearing shorts to those wearing pants.[42] While the color of clothing is relatively easy to observe and may have some influence on heat transfer, other clothing characteristics that are important to consider were not captured, such as air flow and fabric type. Heat exchange, as it relates to clothing, is influenced by the insulating ability of the material, air movement, and relative humidity.[43] In general, detailed clothing characteristics and behaviors were difficult to validate using notes recorded by field observers. In future studies, photographs taken at the beginning and end of the work shift may assist in determining the type of clothing and whether or not layers were removed, a behavior that otherwise difficult to capture.

Limitations

This study has several important limitations. First, outdoor crop workers in WA were not randomly sampled. Participating workplaces may have been more likely to engage in HRI prevention, leading to an underestimate of HRI symptom prevalence. It is also possible that workers that participated are systematically different than all WA outdoor crop workers. Second, the HRI outcome, and personal and workplace risk factors, were self-reported. Risk factor analyses incorporating an outcome of heat strain estimated from core body temperature and heart rate, using established methods such as the Physiological Strain Index,[39] could provide further insight into HRI risk. In comparable populations, objective

measures could complement survey questions that were determined to be reasonably reliable and valid in this study (Appendix 4). Third, this study is cross sectional and relatively small. There may not have been sufficient power to identify all HRI risk factors. Finally, the results of this study, which was conducted in Latino crop workers in WA, may not be generalizable to all crop workers.

Conclusions

In this study of Washington crop workers, decreased age (and less work experience), piece rate pay, and longer distance to the toilet were associated with self-reported HRI. Modifiable workplace factors should be considered in HRI prevention efforts that are evaluated using validated, objective measures in representative working populations.

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Appendix 1. Results of reliability analyses for selected survey questionsa (n=17)

Survey question	% Agreement between participant responses at each survey administration time	Kappa (95% confidence interval[b]), comparing responses at each survey administration time	
		Unweighted	Weighted[c]
Demographics			
Year born	94	0.94 (0.87 – 1.00)	1.00 (0.99 – 1.00)
Gender	100	--	--
Spanish literacy	76	0.62 (0.32 – 0.91)	0.64 (0.12 – 0.95)
English literacy	93	0.85 (0.41 – 1.00)	0.95 (0.63 – 1.00)
Level of education	87	0.83 (0.56 – 1.00)	0.97 (0.88 – 1.00)
Self-identify as Latino/a[d]	100	--	--

Survey question	% Agreement between participant responses at each survey administration time	Kappa (95% confidence interval[b]), comparing responses at each survey administration time	
		Unweighted	Weighted[c]
Location where born[d]	100	--	--
Number of years living in the United States[d]	100	--	--
Live in the United States year-round[d]	94	--	--
Work history, training, acclimatization			
Number of seasons worked in orchards	63	0.49 (0.17 – 0.80)	0.70 (0.20 – 0.95)
Time of year participant started working for the season	79	0.61 (0.22 – 1.00)[e]	0.35 (–0.14 – 1.00)[e]
Training about working outdoors in the heat or health effects of working in the heat in last 12 months	73	0.33 (−0.17 – 0.83)	--
Participant gradually increased number of hours of work when they started outdoor work for the season	76	0.51 (0.10 – 0.93)	--
Work breaks			
Length of morning break	88	0.65 (0.19 – 1.00)	--
Length of lunch break	100		
Length of afternoon break	67	0.25 (−0.14 – 0.70)	--
Participant feels they are allowed to take extra breaks	81	0.46 (−0.06 – 0.97)	--
Workplace hydration			
Drink cold or iced water/beverages when hot[d]	94	--	--
Buy water at work[d]	88	--	--
Health status, conditions, and behaviors			
Participant has certain diagnosed health conditions that are risk factors for heat-related illness	85	0.69 (0.00 – 1.00)	--
Self-reported health status	65	0.50 (0.20 – 0.80)	0.79 (0.57 – 0.93)
Frequency of cigarette/tobacco use[d]	100	--	--
BMI category	75	0.57 (0.21– 1.00)	
Heat-related illness, injuries, and concerns			
Experienced health symptoms or illnesses related to working in the heat[d]	94	--	--
Fallen at work because dizzy/faint from the heat	94	0.64 (−0.00 – 1.00)	--
Concern that health affected by working in hot weather	71	0.53 (0.20 – 0.82)	--
Concern that health affected by working in hot weather (dichotomized)[f]	94	0.64 (0.00 – 1.00)	--

[a] "I don't know" responses were treated as missing values and excluded from the analysis.

[b] Analytical for dichotomous variables, and bias-corrected with 1000 bootstrap replications for categorical variables.

[c] Not estimated for dichotomous variables or unordered categorical variables; weights calculated using quadratic weights.

[d] Kappa coefficients and confidence intervals could not be computed because on one date participants all selected the same response. To compute kappa coefficients, each variable must have two or more levels.

[e] Weighted kappa coefficients can be lower than unweighted values when participants select responses at different ends of the spectrum of ordered answer choices. One participant reported starting work during the first half of June on the first survey (a latter ordered option) and before May on the second survey (the first ordered option).

[f] Participants who responded "Very concerned" were compared to those who responded "Not at all concerned," "A little bit concerned," and "I do not have an opinion."

Appendix 2. Results of concurrent validity analyses for selected survey questions (n=17)

Survey response	Percent agreement between survey responses and field observations
Work hours, breaks, payment, and tasks	
Worked in orchard	100
Worked with nectarines and peaches (other tree fruit)	71
Main job task harvesting, thinning green fruit, or pruning	88
Paid hourly	94
Worked for 3 or more days in past week	94
Started working 5–7am	94
Stopped working 12–5pm	94
15 minute morning break	82
30 minute lunch break	100
No afternoon break[a]	73
Exertion	30
Workplace hydration	
Beverages at work	
Water	88
Sports drink	76
Juice	76
Soda	71
Usual frequency of drinks of water[b]	31
Usual frequency of drinks of water (every 30 min or less vs. other)[b]	56
Bring drinking water to work	88
Do not buy water at work	100
Distance to drinking water[b]	100
Distance to toilet[a]	100
Workplace cooling	
Trees available for shade/cooling	100
Removed layers	65
Work clothing	
Headwear	
Any type of hat	88
Ball cap	65
Wide-brimmed hat	76
Bandana	53
Hood	88

Survey response	Percent agreement between survey responses and field observations
Clothing	
Light colored shirt	76
Dark colored shirt	53
Light short sleeve shirt	53
Dark short sleeve shirt	65
Light long sleeve shirt	59
Dark long sleeve shirt	71
Jacket/coat	47
Pants	24
Back brace	94
Body Mass Index (BMI) category[c]	69

[a] Two “I don’t know” responses were treated as missing values and excluded from the analysis.

[b] One “I don’t know” response was treated as a missing value and excluded from the analysis.

[c] Body Mass Index categorized as follows: underweight (below 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (30.0 kg/m^2 and above).

Appendix 3. Key participant survey responsesa

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
Demographics		
Gender		
Male	53	53
Female	47	47
Ethnicity		
Latino/a	99	100
Not Latino/a	1	0
Age (years)		
18–24	14	12
25–34	20	41
35–44	24	29
45–54	25	12
≥ 55	18	6
Country of birth		
United States	7	1
Mexico	91	94
Central America	2	0
Live in US all year		
Yes	93	100
No	7	0
Years living in US		

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
<1	1	0
1–2	2	0
3–4	9	18
5–7	7	12
8–10	9	6
> 10	71	65
Level of education		
Part/all of primary school	54	53
Part/all of middle school	16	12
Part/all of high school	24	24
Part/all of college or university	2	0
I don't know	5	12
Ability to read in Spanish		
Very well	59	47
Fairly well	30	41
Not very well	7	12
Not at all	4	0
Ability to read in English		
Very well	11	18
Fairly well	16	0
Not very well	16	12
Not at all	51	59
I don't know	7	12
Work history, hours, tasks, breaks, training, and acclimatization		
Number of seasons worked in orchards, farms, fields		
< 1	7	0
1–3	11	29
4–5	17	24
6–9	16	6
≥ 10	49	35
I don't know	1	6
Primary work location in past week		
Orchard	86	100
Field	13	0
Outside on tractor	1	0
Crops worked with in past week[b]		
Apples	69	76
Pears	21	0
Cherries	19	35
Other tree fruit	10	12
Hops	4	0

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
Grapes	2	0
Blueberries	4	0
Vegetables	1	0
Other crops	7	0
I don't know	1	0
Main job task in past week		
Pruning	4	0
Thinning blossoms	4	12
Thinning green fruit	20	76
Weeding	5	0
Harvesting	44	6
Sorting	8	0
Packing	1	0
Other job	13	6
How hard has your work been in past week		
Light	30	41
Medium	51	47
Hard	15	6
Very hard	4	0
I don't know	1	6
Payment for main job task in past week		
Hourly	51	94
Piece	50	6
Days worked in past week, mean (sd)	4.9 (1.5)	6.1 (0.3)
Usual time start working in past week		
Before 5am	9	18
Between 5am–7am	89	76
Between 7am–9am	1	0
10am or after	1	6
Usual time stopped working in past week		
Before 10am	1	0
Between 10am–12pm	1	0
Between 12pm–1pm	22	6
Between 1pm–3pm	60	71
Between 3pm–5pm	14	24
5pm or after	2	0
Usual morning break duration (minutes)		
5	5	0
10	9	18
15	66	76
30	5	0

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
No morning break	9	0
Other amount of time	5	6
Usual lunch break duration (minutes)		
15	2	0
30	96	100
45	1	0
Other amount of time	1	0
Usual afternoon break duration (minutes)		
5	4	6
10	7	0
15	45	18
30	3	6
No afternoon break	37	65
Other amount of time	2	0
I don't know	1	6
Feels as if allowed to take extra breaks to rest or hydrate		
Yes	74	76
No	22	18
I don't know	4	6
Heat-related illness training in last 12 months		
Yes	33	18
No	65	71
I don't know	2	12
Time of year started working for the season		
Before May	49	53
During first half of May	16	18
During last half of May	9	6
During first half of June	16	12
During last half of June	4	0
After June	5	0
I don't know	2	12
Gradually increased number of hours of work when started outdoor work this season		
Yes	34	41
No	65	59
I don't know	1	0
Workplace hydration		
Beverages consumed at work in past week[b]		
Water	96	94
Sports drink	23	35
Energy drink	6	18

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
Juice	8	6
Iced coffee or tea	1	0
Hot coffee or tea	3	0
Soda	31	29
Other drink	1	0
Usual frequency of water consumption in past week		
Every 30 minutes or more	57	35
Every hour	26	29
Every hour and half	2	12
Every two hours	12	18
Every three hours	1	0
Every four hours	1	0
I don't know	1	6
Drink water provided versus bring own water in past week[b]		
Drank provided water	24	24
Brought own water	68	88
Brought water and drank provided water	6	0
Did not drink water	2	0
Buy water at work		
Yes	8	12
No	92	88
Drink cold or iced water/beverages when hot		
Yes	83	100
No	18	0
It makes my bones ache	12	--
Warm water is better for cooling the body	12	--
It makes me feel nauseous	6	--
I could get sick	59	--
Other reason	12	--
Reason for drinking less water at work than desired[b]		
Toilet not nearby	6	6
Toilet dirty	9	18
Did not want to take break	3	0
Water too far	4	0
Water ran out	1	0
Not allowed to take break	0	0
Trying to lose weight	1	0
Did not want to drink water provided at work	4	6
Did not bring water with me	1	0

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
Other reason	1	0
I drank what I wanted to at work	72	65
I don't know	3	6
Important water characteristics to consider before drinking[b]		
Color	51	71
Taste	62	65
Temperature	73	82
Source	34	24
Close to toilet	14	12
Close to working location	31	24
Cups available	12	6
Other reason	14	0
Usual time to walk to drinking water (minutes)		
<1	28	18
1–3	31	41
3–5	12	12
5–10	1	0
>10	0	0
Drinking water with participant	27	24
No drinking water available	1	6
Usual time to walk to toilet (minutes)		
<1	16	24
1–3	50	47
3–5	27	29
5–10	7	0
>10	0	0
I don't know	1	0
Workplace cooling		
Cooling aids available[b]		
Trees	92	94
Shade structures/rest stations	13	0
Fans/air conditioners	3	0
No cooling opportunities available	4	6
Remove layers or unbutton/unzip clothing when felt hot in past week		
Yes	33	24
No	67	76
Work clothing		
Headwear usually worn in past week[b]		
Baseball cap	76	65
Wide brimmed hat	23	24
Bandana	26	18

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
Hood from hooded sweatshirt	16	24
No hat/headwear	1	0
Type of clothing usually worn in past week[b]		
Light short-sleeve	9	12
Dark short-sleeve	5	12
Light long-sleeve	68	47
Dark long-sleeve	22	24
Pants	47	29
Jacket/sweatshirt over work clothes	13	6
Other	2	0
Wore girdle/Spanx in past week		
Yes	10	6
No	88	94
I don't know	2	0
Wore back brace in past week		
Yes	11	0
No	89	100
Wore personal protective equipment in past week		
Yes	13	12
No	73	71
I don't know	13	18
Health status, conditions, medications, and behaviors		
BMI category (n=85, n=12)		
Normal (BMI: 18.5–24.9)	27	8
Overweight (BMI: 25.0–29.9)	52	58
Obese (BMI: 30 and above)	21	33
General health status		
Excellent	18	18
Very good	12	6
Good	42	47
Fair	28	29
Health conditions identified by healthcare provider[b]		
Diabetes	13	6
High blood pressure	13	12
Heart disease	0	0
Asthma/lung disease	1	0
Overweight/obese	8	0
None	62	65
I don't know	9	18
Medications taken in past week[b]		

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
High blood pressure	12	12
Depression/mental health	2	0
Constipation	3	0
Cough/allergies/congestion	4	6
Thyroid	2	0
Nausea	1	6
None	72	71
I don't know	6	12
Illness in past week[b]		
Diarrhea/vomiting	2	6
Cold/flu	2	6
Skin infection	1	6
Fever	2	0
None	92	82
I don't know	2	0
Frequency of current tobacco use		
Every day	4	0
Some days	3	0
Not at all	92	100
I don't know	1	0
Days with ≥ 1 alcoholic drink in past week		
1	16	18
2	4	0
3	0	0
4	2	6
5	0	0
6	0	0
7	3	0
None	74	76
I don't know	1	0
Number drinks when consumed alcohol (n=25, n=4)		
1 or 2	60	75
3 or 4	20	25
5 or 6	8	0
More than 6	4	0
Don't know	8	0
Sleep quality in past week		
Very/fairly good	96	88
Fairly/very bad	4	12
Physical exercise outside of work		
Yes	50	24

Survey topic/question	All survey respondents (N=97)	Reliability/validation subset of survey respondents, first survey administration date (N=17)
No	50	71
Don't know	1	6
Additional physical jobs		
Yes	11	12
No	89	88
Heat-related illness, injuries, and concerns		
Experienced the following symptoms during hot day at work in the past week[b]		
Rash	3	12
Cramps	1	0
Light headedness/Dizziness	3	0
Fainting	0	0
Headache	19	29
Heavy sweating	28	18
Fatigue	2	0
Nausea/vomiting	2	6
No symptoms	53	29
I don't know	1	6
Ever fallen at work because dizzy/faint from the heat		
Yes	8	12
No	92	88
Concern about health affected by working in hot conditions		
Not at all concerned	23	35
A little bit concerned	52	47
Very concerned	19	12
No opinion	7	6
Know about weather before going to work		
Yes	52	41
No	44	53
Don't know	4	6

[a] Percent unless otherwise indicated; percents may not sum to 100 due to rounding

[b] Exceeds 100% because more than one answer could be selected

Appendix 4. Suggested survey questions and recommendations based on survey evaluation results

Survey question	Comments/Recommendations
A) How many seasons have you been working in orchards, vineyards, farms, or in fields?	Ensure "seasons" is interpreted as intended by target audience.
Less than 1 season	
1 to 2 seasons	

Survey question	Comments/Recommendations
3 to 5 seasons	
6 to 9 seasons	
10 or more seasons	
I don't know	
B) When did you start working outdoors this season on orchards, vineyards, farms, or in fields?	
Before May	
During the first half of May	
During the last half of May	
During the first half of June	
During the last half of June	
After June	
I don't know	
C) In the past week, what crops have you worked with?	Link each crop to a list of tasks specific to that crop; adapt to relevant crops.
Apples	
Pears	
Cherries	
Other tree fruit	
Hops	
Grapes	
Blueberries	
Other berries	
Vegetables	
Other crops	
I don't know	
D) In the past week, what has been your main job task?	Consider developing separate questions with relevant tasks/answer choices that branch from the types of crops selected in the previous question.
Pruning	
Thinning blossoms	
Thinning green fruit	
Planting	
Working with grape vines	
Tying hop vines	
Weeding	
Harvesting crops	
Applying pesticides	
Sorting fruits or vegetables	
Packing fruits or vegetables	
Other jobs not listed here	
I don't know	

Survey question	Comments/Recommendations
E) This question is asking about your main job task in the past week. How were you paid for your work?	
By the hour	
Piece rate	
Other payment method	
I don't know	
F) In the past week, how many days did you work?	
1	
2	
3	
4	
5	
6	
7	
I did not work this past week	
I don't know	
G) In the past week, at what time of day have you usually started working?	Consider re-formatting answer choices, so times do not overlap. For example, state "At or after 5am and before 7am." The approach used here is simpler and was preferred by our target audience during testing. Alternate approaches should be evaluated by the target audience.
Before 5 am	
Between 5 am and 7 am	
Between 7 am and 9 am	
Between 9 am and 10 am	
10 am or after	
I don't know	
H) In the past week, at what time of day have you usually stopped working?	Consider re-formatting answer choices, so times do not overlap. For example, state "At or after 1pm and before 3pm." The approach used here is simpler and was preferred by our target audience during testing. Alternate approaches should be evaluated by the target audience.
Before 10 am	
Between 10 am and 12 pm	
Between 12 pm and 1 pm	
Between 1 pm and 3 pm	
Between 3pm and 5 pm	
5 pm or after	
I don't know	
I) How long is your morning break usually?	Consider prefacing with a recall period, such as "in the past week."
5 minutes	
10 minutes	

Survey question	Comments/Recommendations
15 minutes	
30 minutes	
I don't take a morning break	
Other amount of time	
I don't know	
J) How long is your lunch break usually?	Consider prefacing with a recall period, such as "in the past week."
15 minutes	
30 minutes	
45 minutes	
1 hour	
I don't take a lunch break	
Other amount of time	
I don't know	
K) How long is your afternoon break usually?	Consider prefacing with a recall period, such as "in the past week." Consider removing "I don't take an afternoon break" and asking a separate question about whether participant regularly takes afternoon breaks, because afternoon breaks may not be as consistent as morning and lunch breaks.
5 minutes	
10 minutes	
15 minutes	
30 minutes	
I don't take an afternoon break	
Other amount of time	
I don't know	
L) Do you feel like you are allowed to take extra breaks if you need to rest or drink water?	
Yes	
No	
I don't know	
M) In the past week, where have you been doing most of your work?	
In an orchard	
In a field	
Outside on a tractor	
Outside on a tractor in a cab	
In a shed or tent	
In a shop	
In a packing house	
In a different location	
I don't know	

Survey question	Comments/Recommendations
N) When you started doing outdoor work this season, did you begin working a few hours per day and gradually increase the number of hours of work?	Combine with other methods to assess acclimatization.
Yes	
No, I began with the full number of hours of work	
I don't know	
O) How hard has your work been in the past week?	Combine with other methods to assess effort.
My work was light	
My work was medium	
My work was hard	
My work was very hard	
I did not work	
I don't know	
P) In the past week, what did you drink at work?	Combine with other methods to assess hydration.
Water	
Sports drinks like Gatorade or Cytomax	
Energy drinks like Red Bull, Monster, or 5-hour Energy	
Fruit juice	
Iced coffee or iced tea	
Hot coffee or hot tea	
Soda	
Other drinks not listed here	
I don't know	
Q) In the past week, if you drank less water than you wanted to drink at work, why?	Consider reducing the number of answer choices, including those that are most relevant to the study population.
Toilet was not nearby	
Toilet was dirty	
I didn't want to take a break to get a drink	
Water provided at work was too far away	
Water provided at work ran out	
I am not allowed to take a break to get a drink	
I was trying to lose weight	
I didn't want to drink what was provided at work	
I didn't bring any water with me	
Other reason	
I drank the amount of water that I wanted to at work	
I don't know	
R) How long does it usually take you to walk to where there is drinking water?	Combine with other methods to assess distance to drinking water.
Less than one minute	
Between one to three minutes	

Survey question	Comments/Recommendations
Between three to five minutes	
Between five to ten minutes	
More than ten minutes	
I don't have to walk because my drinking water is with me	
There is no drinking water	
I don't know	
S) How long does it usually take you to walk to the toilet?	Combine with other methods to assess distance to toilet.
Less than one minute	
Between one to three minutes	
Between three to five minutes	
Between five to ten minutes	
More than ten minutes	
I don't know	
T) In the past week, did you drink water provided for you at work, or did you bring your own water to drink at work?	Consider asking two separate questions: Did you drink water provided for you at work? Yes, No, Don't know; and Did you bring your own water to drink at work? Yes, No, Don't know.
I drank the water that was provided	
I brought my own water to drink	
I did not drink water at work	
I don't know	
U) Do you buy water at work?	
Yes, all the time	
Yes, some of the time	
No	
I don't know	
V) Do you drink cold or iced water or other cold beverages to cool yourself when you are feeling hot?	
Yes	
No	
I don't know	
W) At your current workplace, are any of the following available to help keep workers cool?	Adapt to cooling methods used at target workplaces.
Shade structure	
Trees	
Fans	
Rest stations	
Building with air conditioning	
Other cooling methods not listed here	
There are no cooling methods available at work	
I don't know	

Survey question	Comments/Recommendations
X) In the past week, did you remove layers or unbutton or unzip clothing when you felt hot?	Combine with other methods to assess clothing.
Yes	
No	
I don't know	
Y) Would you say that in general your health is:	
Excellent	
Very good	
Good	
Fair	
Poor	
I don't know	
Z) In the past week, how well did you sleep?	
Very good	
Fairly good	
Fairly bad	
Very bad	
I don't know	
AA) Has a doctor or other health provider ever told you that you have any of the following conditions?	
Diabetes	
High blood pressure	
Heart disease	
Lung disease, including asthma	
Overweight or obese	
Malaria	
No, I do not have any of these medical conditions	
I don't know	
BB) In the past week, have you taken pills or medication for any of the following medical conditions, symptoms, or reasons?	Consider reducing the number of answer choices based on expected prevalences of conditions.
High blood pressure	
Mental health conditions, including depression	
Diet pills	
Parkinson's disease	
Heart disease	
Constipation	
Irritable bowel or bladder	
Nose congestion, cough, or allergies	
Seizures	
Thyroid condition	
Nausea	

Survey question	Comments/Recommendations
No, I have not taken pills or medications for the reasons listed here	
I don't know	
CC) In the past week, other than your regular job, did you participate in any physical activities or exercise such as running, soccer, gardening, or walking for exercise?	
Yes	
No	
I don't know	
DD) In the past week, have you had other paid jobs that require physical work?	
Yes	
No	
I don't know	
EE) Do you now smoke cigarettes, cigars, or pipes or chew tobacco every day, some days, or not at all?	
Every day	
Some days0	
Not at all	
I don't know	
FF) In the past week, on how many days did you have at least one drink of any alcoholic beverage such as a beer, glass of wine, or a drink with liquor?	
1 day	
2 days	
3 days	
4 days	
5 days	
6 days	
7 days	
I did not drink any alcohol this past week	
I don't know	
GG) In the past week, on the days when you had beer, wine, or liquor, about how many did you drink on average?	
1 or 2	
3 or 4	
5 or 6	
More than 6	
I don't know	
HH) How concerned are you about your health being affected by working in hot conditions?	Consider dichotomizing into "Very concerned" versus other choices in analysis.
Not at all concerned	
A little bit concerned	
Very concerned	
I do not have an opinion	

Survey question	Comments/Recommendations
II) In the past week, did you ever experience any health symptoms or illnesses that you think may have been related to working in the heat?	Combine with physiological measures of heat strain.
Yes	
No	
I don't know	
JJ) Have you ever fallen at work because you felt dizzy or faint from the heat?	
Yes	
No	
I don't know	
KK) In the past week, did you ever experience any of the following symptoms or illnesses during a hot day at work?	Combine with physiological measures of heat strain.
Skin rash or skin bumps	
Painful muscle cramps or spasms	
Dizziness or light-headedness	
Fainting	
Headache	
Heavy sweating	
Extreme weakness and fatigue	
Nausea or vomiting	
Confusion	
Other symptoms or illnesses	
I did not experience any of these symptoms or illnesses	
I don't know	
LL) In the last 12 months, did you receive any training about working outdoors in the heat or health effects of working in the heat?	Consider adding knowledge questions to assess workers' knowledge of heat-related illness.
Yes	
No	
I don't know	
MM) What year where you born?	
(List of answer choices from "Before 1948" to 1995)	
NN) Are you male or female?	
Male	
Female	
OO) How well can you read in Spanish?	
Very well	
Fairly well	
Not very well	
Not at all	
I don't know	
PP) How well can you read in English?	
Very well	

Survey question	Comments/Recommendations
Fairly well	
Not very well	
Not at all	
I don't know	
QQ) What level of education did you complete?	
Part of primary school	
Completed primary school	
Part of middle school	
Completed middle school	
Part of high school	
Completed high school	
Part of college or university	
Completed college or university	
I don't know	
RR) What is your weight?	
(List of answer choices from 46 kg/101 pounds to 136 kg/300 pounds)	
SS) What is your height?	Consider decreasing the lower bound to capture the height of shorter stature workers.
(List of answer choices from 1.52 m/4 ft 11 inches to 2 m/6 ft 6 inches)	
TT) Do you consider yourself Hispanic or Latino or Latina?	Adapt to study population.
Yes	
No	
I don't know	
UU) How many years have you been living in the United States?	
Less than 1 year	
1–2 years	
3–4 years	
5–7 years	
8–10 years	
More than 10 years	
I don't know	
VV) Do you live in the United States all year?	Consider adding a question about housing conditions.
Yes	
No	
I don't know	
WW) Where were you born?	
United States	
Mexico	
Central America	
South America	

Survey question	Comments/Recommendations
Other	
I don't know	

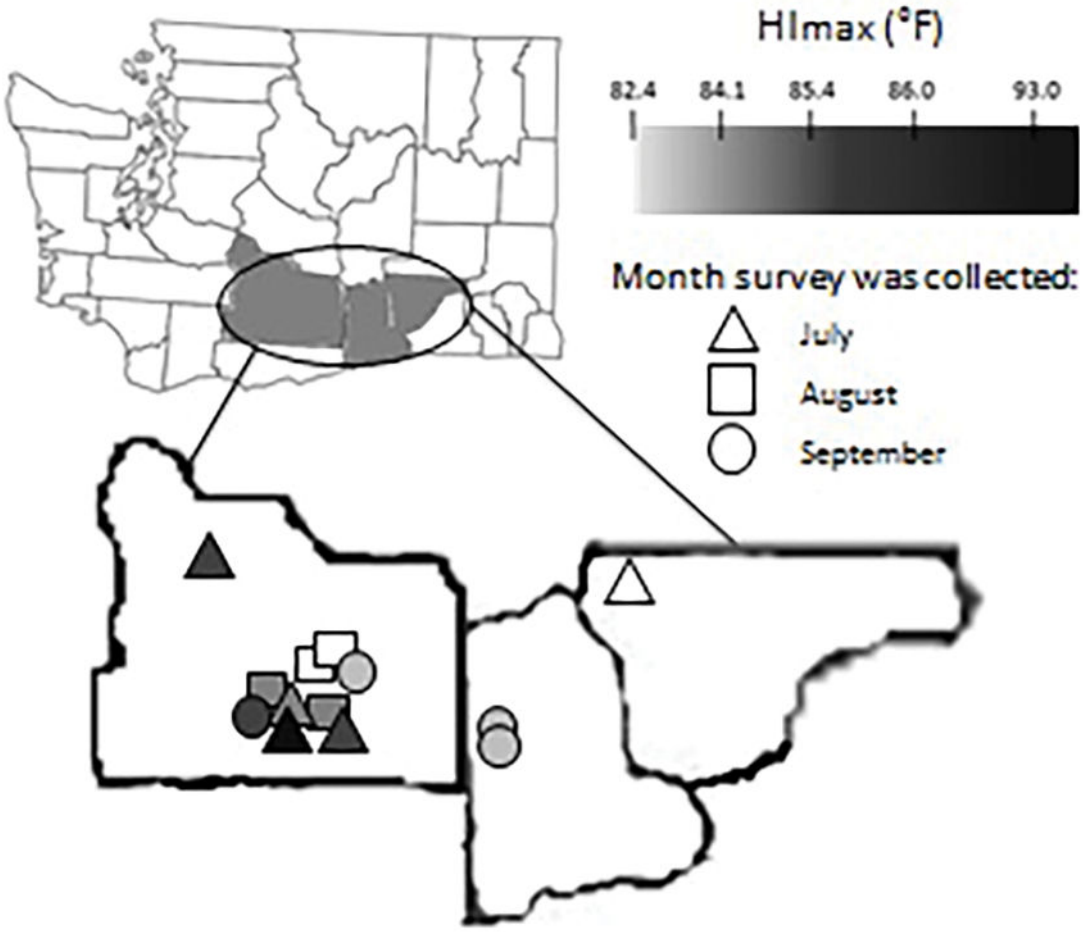

Figure 1.
Spatiotemporal distribution of HI_{max}, the mean maximum daily heat index over the week prior to survey completion, the duration of recall of most survey questions.

Table 1

Potential HRI risk factors by HRI status (percent or mean [SD])

Potential risk factor	No HRI (n=67)	HRI (n=30)	Total (N=97)
Demographic			
Age (years)	43 (13)	36 (13)	41 (13)
Male (vs female)	55	47	53
Training			
No HRI training (vs HRI training)	65	70	66[a]
Work factors			
Piece-rate pay (vs hourly pay)	42	67	49
No extra breaks (vs extra breaks)	22	24	22[b]
Hard/very hard work (vs light/medium work)	17	23	19[c]
> 3 min walk to toilet (vs < 3 min)	29	47	34[c]
Hydration			
Drank caffeine[d] (vs did not drink caffeine)	31	37	33
Drank less than every 30 minutes (vs drank every 30 minutes or more often)	42	45	43[c]
Clothing			
No light-colored shirt (vs light-colored shirt)	24	23	24
Health			
Body mass index (kg/m^2)	28 (4)	28 (5)	28 (4)[e]
Good/fair general health (vs excellent/very good health)	67	77	70
Diabetes mellitus and/or anti-hypertensive medication use (vs no diabetes and/or antihypertensive use)	27	21	25[f]
Environmental conditions			
Mean maximum daily heat index (°F)	84 (2)	83 (2)	84 (2)

HRI = heat-related illness, defined as self-reported dizziness/lightheadedness or heavy sweating during a hot day at work in the past week;

[a] 2 observations missing;

[b] 4 observations missing;

[c] 1 observation missing;

[d] energy drinks, coffee, or soda;

[e] 3 observation missing;

[f] 9 observations missing

Table 2

Odds ratios (95% confidence intervals) of HRI by potential risk factor[a]

Potential risk factor	Odds ratio	95% confidence interval
Demographic		
Age	0.92	0.87–0.98
Male (reference: female)	0.75	0.22–2.59
Work factors		
Piece-rate pay (reference: hourly pay)	6.20	1.11–34.54
No extra breaks (reference: extra breaks)	1.38	0.34–5.64
Greater than 3 min walk to toilet (reference: less than 3 minutes)	4.86	1.18–20.06
Hydration		
Drank caffeine[b] (reference: did not drink caffeine)	0.49	0.11–2.30
Health		
Good/fair general health (reference: excellent/very good)	1.26	0.33–4.90
Diabetes mellitus and/or anti-hypertensive medication use (reference: no diabetes and/or antihypertensive use)	0.79	0.18–3.41

HRI = heat-related illness

[a] Final mixed effects logistic regression model, with random effect for workplace, adjusted for all variables in table.

[b] Energy drinks, coffee, or soda